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Conducted in June of 1978 was the joint Soviet-American experiment (Project JASPIC) with the following basic goals: 1) the study of flows of spilling electrons which act upon the middle-latitude ionosphere under nocturnal conditions (nocturnal corpuscular source of ionization), and 2) the mutual comparison of procedures for registering corpuscular radiations in the upper atmosphere, using meteorological and geophysical rockets. /1*

In order to preclude latitudinal, longitudinal, and sporadic variations to which corpuscular flows are subjected, the measurements were carried out simultaneously at close geographical points. The launches of the American geophysical rockets were conducted on the USA range (Wallace Flight Center, WFC, $38^{\circ},7$ N, $75^{\circ},5$ W), while the Soviet MR-12 meteorological rockets were launched from onboard the scientific research vessel "Professor Vize", located in the Atlantic Ocean several kilometers from the indicated range.

Presented in the current study are the results obtained in the process of implementation of the Soviet part of the program of the experiment.

Equipment

Three types of equipment were installed on the meteorological rockets to measure the flow of electrons: the "Fosfor"

*Numbers in the margin indicate pagination in the foreign text.

type apparatus, a type SKr-2M spectrometer of geoactive corpuscular radiations, and a block of "Elektron" geiger counters. Utilized in the "Fosfor" apparatus [1] as a detector was the thermoluminescent phosphor $CaSO_4$-Mn. This apparatus makes it possible to measure the flow of electrons with an energy $E_e \geq 2$ kev, and, by using filters, one can pick out flows of electrons with energies $E_e \geq 5$ and $E_e \geq 7$ kev, as well as resonance luminescence of the atmosphere in the HL_α line (λ=1216 Å). There were 2 instruments mounted on the rockets, one of which was directed at the zenith, and the other at an angle of $\sim 45^\circ$ to the vertical. The SKr-2m spectrometer [2], based on the utilization of electrostatic cylindrical analyzers and channel multipliers, made it possible to obtain the energetic spectra of the electrons in the particle energy range Ee=0.5-10 kev. The "Elektron" instrument was designed for measuring the integral intensity of the electrons with an energy $E_e \gtrsim 40$ kev. /2

Results

We will move to an examination of the results of the measurements of the flows of spilling electrons. Given in the table are the dates and time (Greenwich) of the launches of the MR-12 meteorological rockets, the zenith angles of the sun ($Z_\odot$), the three-hour values of the planetary (Kp) and local (K, according to the data of the Fredericksburg station) indexes of the geomagnetic field, and the flow of radio radiation of the sun in a 10.7 cm wave ($F_{10.7}$, Ottawa). Presented in the table also are some parameters of the flows of spilling electrons, recorded at altitudes of over ~150 km, using the devices indicated above: W is the energy flow in ergs/cm^2·sec·steradian, Ne ($\geq$ 40 kev) is the integral intensity of the electrons with energies over 40 kev.

First and foremost, we would note that the data on the flows of electrons, obtained using the various devices, agrees satisfactorily among themselves, and supplement each other. /3

TABLE

№№	Дата[a]	UT[b] час: мин.	$Z_\odot$	Kp	K	$F_{10.7}$	"Фосфор"[c] W эрг/см²с.ср.[f] E ≥ 7 кэВ[g]	"СКр-2М"[d] W эрг/см²с.ср.[f] E ≥ I кэВ[g]	"Электрон"[e] N_e(≥ 40кэВ)[g] част/см²с.ср[h]
I.	II.06.78	06.27	II6^0	5-	4	II0	$7.I0^{-5}$	$3.I0^{-3}$	$I,6.I0^{I}$
2.	20.06.78	04.I0	II8^0	3-	3	I69	$3.I0^{-5}$	$3.I0^{-4}$	$0,5.I0^{I}$
3.	24.06.78	02.I3	I07^0	5-	5	I89	-	$4.I0^{-5}$	$0,6.I0^{I}$
4.	26.06.78	0I.3I	I02^0	4	4	I78	$5.I0^{-5}$	$(0,8\div8).I0^{-4}$	-

Key: a. Date
b. Time, hrs. and min.
c. "Fosfor"
d. "SKr-2M"
e. "Elektron"
f. ergs/cm²·sec·steradian
g. kev
h. particles/cm²·sec·steradian

Given in more detail in the figure are the results of the measurements obtained in the indicated four launches of MR-12 meteorological rockets, using the "SKr-2M" spectrometer and the "Elektron" block (the numbers 1-4 in the figure correspond to the launch numbers from the table).

Given in each part of the figure at the top are the values, measured during the flight of the meteorological rockets, of the differential intensities of the electrons in different parts of the energetic spectrum (plotted along the x-axis is the time, in seconds, from the moment of start and the flight altitude for each launch). Given on the left are the values of the average energies for each measured section of the spectrum, and the intensities, which correspond to the unit spectrum of the SKr-2M spectrometer, are indicated. In the ideal case (with a background rate of counting of less than 0.1 pulse/sec), the sensitivity of the spectrometer is an order

higher than the unit spectrum, which was achieved because of the 10-second exposure of the measurement of the intensity in each energetic interval. Given in the lower part of the figure are the integral intensities of the electrons with an energy $E_e \geq 40$ kev. Indicated in the figure are either the statistical errors of the measurements or the upper values of the differential intensities (downward arrows), which were determined by the background readings of the spectrometers for each concrete cycle of measurement of the energetic spectra of the electrons.

As is evident from the figure, the flows of electrons are recorded sufficiently reliably only in launch No. 1, and partly in launch No. 4 (with greater statistical errors). For launches No. 2 and 3, one can only indicate the upper values of the energy flows, insofar as the readings of the spectrometers either slightly exceeded the background rate of counting (launch No. 2) or they corresponded to it (launch No. 3).

From the measurements of the two "Fosfor" instruments, we managed to establish that the flows of electrons from the magnetic zenith is weaker than those occurring at an angle to the magnetic force line. Thus, it was again shown that, with rocket measurements of the flows of electrons, it is important to take into account their pitch-angle distribution.

On the whole, the conducted experiment again confirmed the fact that the intensity of nocturnal corpuscular flows, acting on the middle-latitude atmosphere, undergoes considerable variations—in the given case, from $W\ 4 \cdot 10^{-5}$ to $W = (2\text{-}4) \cdot 10^{-3}$ ergs/cm$^2 \cdot$sec$\cdot$steradian. We had noted earlier (see, for example, [3,4]) that the intensity of spilling electrons depends on the perturbed state of the geomagnetic field—as a rule, it increases during periods of geomagnetic storms. /4

The presented results, for all appearances, do not contradict the tendency established earlier. Actually, launch No. 1, in which the maximum flow of spilling electrons for the given experiment was recorded, was carried out either during the period of a magnetic substorm, or right after it—roughly six hours prior to the launch, the indexes Kp and K reached values of 6.

Conclusions

1. The current experiment corroborates the results of previous investigations [3-7] of flows of spilling electrons, given using analogous procedures, proceeding from the supportable fact that flows of electrons, acting on the nocturnal middle-latitude ionosphere, vary within considerable limits (up to three or more orders of magnitude).

2. The observed considerable variations of the flows of spilling electrons, to all appearances, are brought about by geomagnetic perturbations. We would only note that the established dependence of the intensity of the spilling electrons on the condition of the geomagentic field bears a probability, rather than a functional, nature.

3. The conducted experiment makes it possible to assert that flows of spilling electrons play a substantial role in the formation of the nocturnal middle-latitude ionosphere during periods of geomagnetic perturbations, and, consequently, they are corroboration of the corpuscular hypothesis [8] of ionization of the nocturnal ionosphere.

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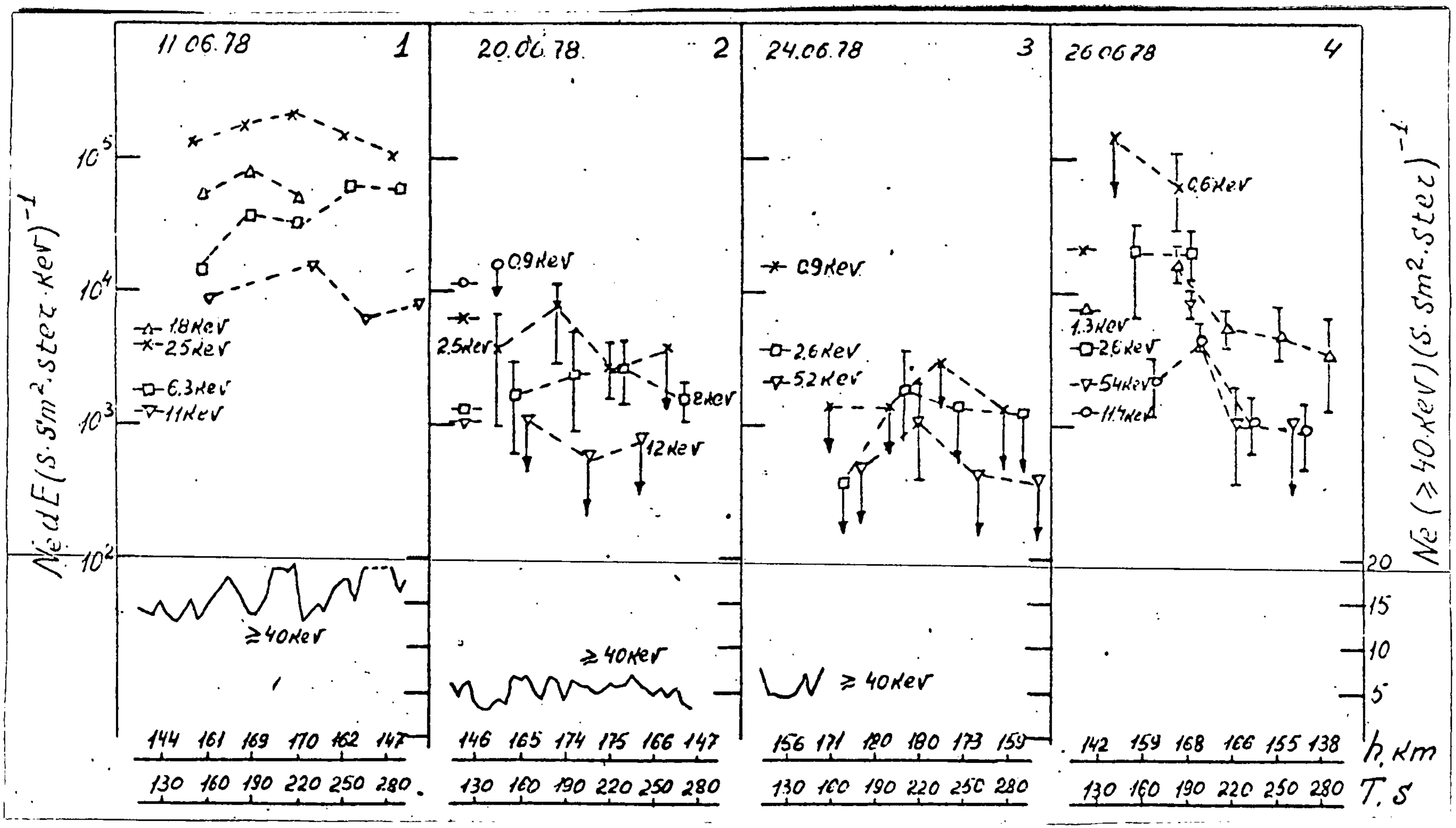
11 06.78
1
20.06.78
2
24.06.78
3
26 06 78
4
$N_e\,dE\,(s\cdot sm^2\cdot ster\cdot keV)^{-1}$
$N_e\,(\geq 40\,keV)\,(s\cdot sm^2\cdot ster)^{-1}$
10^5
10^4
10^3
10^2
1.8 keV
2.5 keV
6.3 keV
11 keV
0.9 keV
2.5 keV
8 keV
12 keV
0.9 keV
2.6 keV
5.2 keV
0.6 keV
1.3 keV
2.6 keV
5.4 keV
11.4 keV
≥ 40 keV
≥ 40 keV
≥ 40 keV
20
15
10
5
h, km
T, s
144 161 169 170 162 147
146 165 174 175 166 147
156 171 180 180 173 159
142 159 168 166 155 138
130 160 190 220 250 280
130 160 190 220 250 280
130 160 190 220 250 280
130 160 190 220 250 280

97

Caption for Figure

/7

Results of measurement on MR-12 rockets:

1—6/11/78; $06^h\ 27^m$;

2—6/20/78; $04^h\ 10^m$;

3—6/24/78; $02^h\ 13^m$;

4—6/26/78; $01^h\ 31^m$;

Along the y-axis:

At the top—

$J_{Ne}dE$—differential intensity of the flow of electrons in different regions of the energetic spectrum (electrons/cm^2·sec·steradian·kev)

Indicated on the left are the average values of the measurements.

—statistical measurement error;

—measurements determined by background readings of spectrometer.

At the bottom—

J_{Ne} ($\geq$ 40 kev)—integral intensity of electrons with energy Ee$\geq$40 kev (electrons/cm^2·sec·steradian).

Along the x-axis:

h—altitude, in km;

T—time, in seconds, from moment of start.

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16. Abstract

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